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Attorney Reference Number 4641-61168-01

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of: Nakasuji

Application No. 09/996,527

Filed: November 28, 2001

Confirmation No. 3559

For: METHODS AND DEVICES FOR DETECTING AND CANCELING MAGNETIC FIELDS EXTERNAL TO A CHARGED-PARTICLE-BEAM (CPB) OPTICAL SYSTEM, AND CPB MICROLITHOGRAPHY APPARATUS AND METHODS COMPRISING SAME

Examiner: James P. Hughes

Art Unit: 2881

Attorney Reference No. 4641-61168-01

CERTIFICATE OF MAILING

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CERTIFICATION

I certify that the attached English translation is a true and literal translation of the corresponding Japanese patent application no. 2000-368005.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.

Date: 6/21/04 Fumiyo S. Bennett

STATE OF Oregon)
) ss.
COUNTY OF Multnomah)

This 21st day of June, 2004, before me personally came the above-named Fumiyo S. Bennett, who executed the foregoing instrument in my presence, and who acknowledged to me that he executed the same of his own free will for the purposes set forth therein.

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[SEAL]

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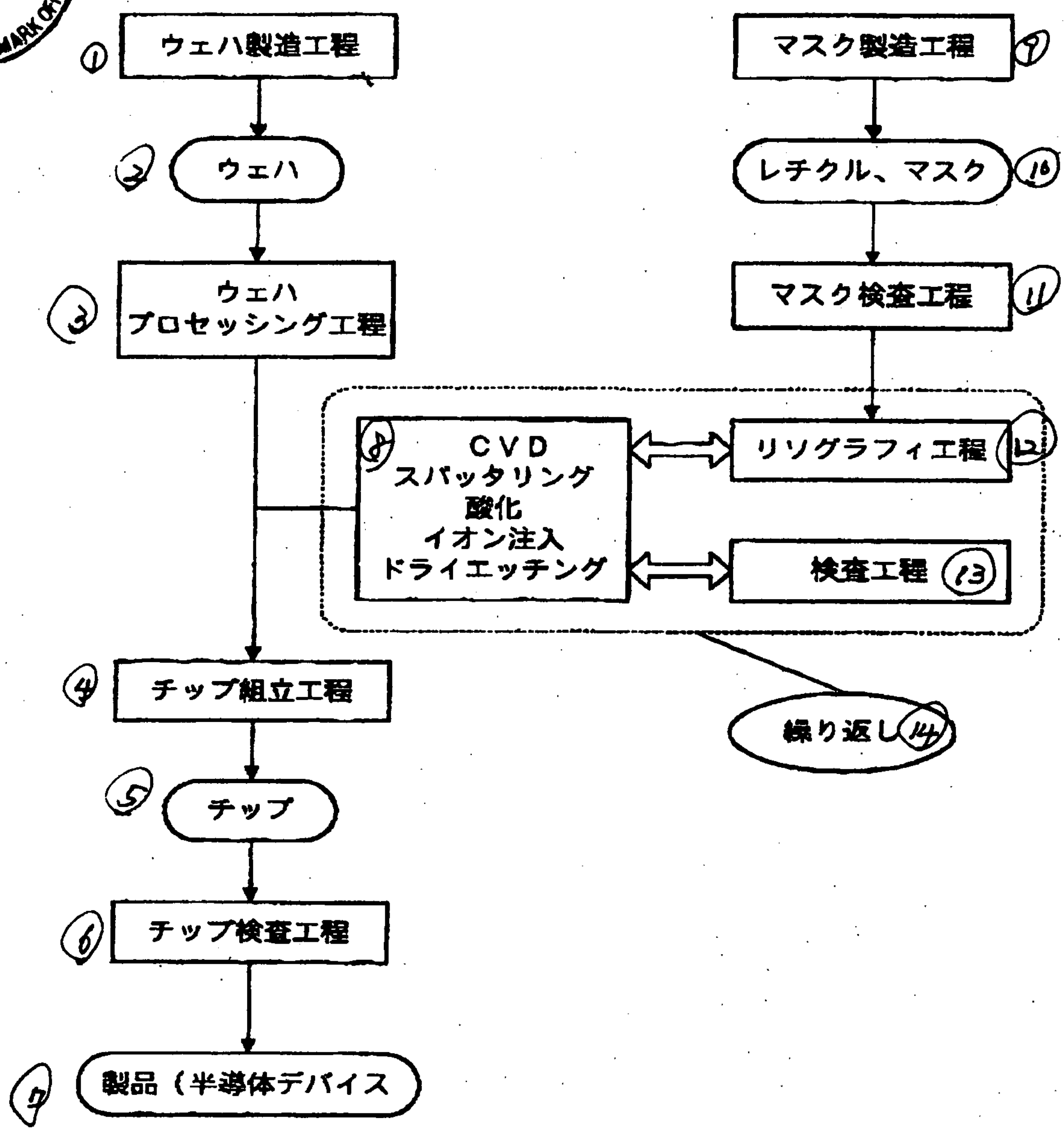
My commission expires: 3/8/08

【図３】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Document Name: Specification

Title of Invention: Charged Particle Beam Exposure Apparatus, Charged Particle Beam Exposure Apparatus Adjustment Method and Semiconductor Device Method of Manufacture

Claims

Claim 1 A charged particle beam exposure apparatus that illuminates a reticle on a reticle stage by means of an illumination optical system and transfers the pattern formed on the reticle to a wafer on a wafer stage by means of a projection optical system; characterized in that it has a magnetic sensor that detects fluctuating magnetic fields and a magnetic field compensation coil at at least one of the interval between the illumination optical system and the projection optical system or the interval between the projection optical system and the wafer stage, and in

that it has a magnetic field compensator that adjusts the electric current that flows to the magnetic field compensation coil so that the fluctuating magnetic fields detected by the magnetic sensor can be compensated.

Claim 2 The charged particle beam exposure apparatus described in Claim 1; characterized in that the magnetic sensor and the magnetic field compensation coil provided in the interval between the illumination optical system and the projection optical system are provided between the illumination optical system and the reticle stage.

Claim 3 The charged particle beam exposure apparatus described in Claims 1 or 2; characterized in that the said magnetic sensor and magnetic field compensation coil respectively consist of three sets of coils, where the magnetic sensor detects magnetic fields in the directions of each of the axes in an x-y-z rectangular coordinate system in which the optical axis of the illumination optical system and the projection optical system is the z axis, and the three sets of magnetic field compensation coils respectively generate magnetic fields in the directions of each of the axes in an

x-y-z rectangular coordinate system.

Claim 4 The charged particle beam exposure apparatus described in Claim 3; characterized in that the magnetic sensor consists of

(1) a coil that is wrapped centering on said z axis and detects magnetic fields in the z axis direction,

(2) a coil that is wrapped about an axis parallel to the x axis and detects magnetic fields in the x axis direction, and

(3) a coil that is wrapped about an axis parallel to the y axis and detects magnetic fields in the y axis direction,

and in that the three sets of magnetic field compensation coils consist of

(1) a coil that is wrapped centering on said z axis and generates magnetic fields in the z axis direction,

(2) a coil that is wrapped about an axis parallel to the x axis and generates magnetic fields in the x axis direction,

(3) a coil that is wrapped about an axis parallel to the y axis and generates magnetic fields in the y axis direction.

Claim 5 A charged particle beam exposure apparatus described in any one of Claims 1 through 4; characterized in that said magnetic sensor is provided so as to be separated from said z axis direction further than said magnetic field compensation coil.

Claim 6 A charged particle beam exposure apparatus described in any one of Claims 1 through 4; characterized in that said magnetic sensor consists of a coil, and this coil also acts as a magnetic field compensation coil.

Claim 7 An adjustment method for a charged particle beam exposure apparatus described n any one of Claims 1 through 6; characterized in that the ratio of the magnetic field detected by the magnetic sensor and the electric current that flows to the magnetic field compensation coil is experimentally obtained in advance, and the electric current that flows to the compensation coil is determined based on the actually detected magnetic field and this

ratio.

Claim 8 A semiconductor device method of manufacture characterized in that it results from having a process that uses an electron beam exposure apparatus described in any one of Claims 1 through 6 and exposure transfers the image of the pattern formed on a mask or a reticle onto a mask.

[Detailed Description of the Invention]

[0001] Technical Field of the Invention

The present invention pertains to a charged particle beam exposure apparatus that has a function that compensates for the effects of floating magnetic fields, a method of adjusting same, and a semiconductor device method of manufacture that uses this charged particle beam exposure apparatus.

[0002] [Prior Art]

As the level of integration required of semiconductor devices becomes higher, it becomes necessary to form circuit patterns whose minimum line width is less than 100 nm on the wafer, and it is becoming impossible to use conventional optical system exposure transfer apparatuses.

Step and repeat exposure transfer system charged particle beam exposure apparatuses have attracted attention as apparatuses that are able to exposure transfer this type of minute line width pattern at high throughput.

[0003] When this type of charged particle beam exposure apparatus is used to perform exposure transfer from a reticle to a wafer, there are cases where the track of the charged particle beam is disturbed and exposure transfer precision deteriorates due to the effects of floating magnetic fields outside the charged particle beam exposure apparatus. It is thought that, as a countermeasure for this, an electric current with the appropriate amplification could be provided to correspond to the floating magnetic field using three coils (approximately 50 cm in diameter) whose axes are mutually perpendicular installed at positions approximately 4 m from the charged particle beam exposure apparatus to negate the floating magnetic field.

[0004] [Problems to be Solved by the Invention]

However, when a Helmholtz coil of approximately 50 cm in diameter is installed at a location 4 m from the charged particle beam exposure apparatus, the problem of interference with other peripheral power sources, etc. as well as the problem of having to make the cleanroom large occur. In addition, in this method, there is a problem in that the floating magnetic field shielding ratio is limited to approximately 1/10, and a sufficient effect cannot be achieved. There is also a problem in that the magnetic field from the magnetic field generation source (for example, a linear motor) between the apparatus and the coil cannot be negated.

[0005] The present invention was devised with these circumstances in mind, and its issue is to provide a charged particle beam exposure apparatus that is able to negate the effects of floating magnetic fields and which has a good shielding ratio without using a large apparatus.

[0006] [Means to Solve Problems]

The first means to solve the aforementioned problems is a charged particle beam exposure apparatus that illuminates a reticle on a reticle stage by means of an illumination optical system and transfers the pattern formed on the reticle to a wafer on a wafer stage by means of a projection optical system; characterized in that it has a magnetic sensor that detects fluctuating magnetic fields and a magnetic field compensation coil at at least one of the interval between the illumination optical system and the projection optical system or the interval between the projection optical system and the wafer stage, and in that it has a magnetic field compensator that adjusts the electric current that flows to the magnetic field compensation coil so that the fluctuating magnetic fields detected by the magnetic sensor can be compensated (Claim 1).

[0007] In this means, the fluctuating magnetic fields (floating magnetic fields) are detected by a magnetic sensor provided within the charged particle beam exposure

apparatus, and electric currents that would negate these fields flow to the magnetic field compensation coil provided within the charged particle beam exposure apparatus. Therefore, it is possible to locally negate the magnetic fields in small coils, so large-scale equipment is not needed, and an effect that combines with the shield effect of ferromagnetic bodies of the envelope of the illumination optical system and the projection optical system can be achieved, so it is easy to make the make the floating magnetic field shielding effect better than 1/30. Note that the floating magnetic fields are external magnetic fields generated by apparatuses other than the charged particle beam exposure apparatus.

[0008] The second means to solve the aforementioned problems is the aforementioned first means; characterized in that the magnetic sensor and the magnetic field compensation coil provided in the interval between the illumination optical system and the projection optical system are provided between the illumination optical system and the reticle stage (Claim 2).

[0009] Reticles are arranged between the illumination optical system and the projection optical system, but generally the space between the illumination optical system and the reticle is wider than that between the reticle and the projection optical system. Therefore, efficient utilization of space can be pursued by providing the magnetic sensor and the magnetic field compensation coil between the illumination optical system and the reticle stage.

[0010] The third means to solve the aforementioned problems is the aforementioned first or second means; characterized in that the aforementioned magnetic sensor and magnetic field compensation coil respectively consist of three sets of coils, where the magnetic sensor detects magnetic fields in the directions of each of the axes in an x-y-z rectangular coordinate system in which the optical axis of the illumination optical system and the projection optical system is the z axis, and the three sets of magnetic field compensation coils respectively generate magnetic fields in the directions of each of the axes in an x-y-z rectangular coordinate system (Claim 3).

[0011] In this means, fluctuating magnetic fields in the directions of the three axes are independently detected, and the magnetic fields that are generated from the respective corresponding coils are negated, so fluctuating magnetic fields can be reliably negated.

[0012] The fourth means to solve the aforementioned problems is the aforementioned third means; characterized in that the magnetic sensor consists of

(1) a coil that is wrapped centering on the aforementioned z axis and detects magnetic fields in the z axis direction,

(2) a coil that is wrapped about an axis parallel to the x axis and detects magnetic fields in the x axis direction, and

(3) a coil that is wrapped about an axis parallel to the y axis and detects magnetic fields in the y axis direction,

and in that the three sets of magnetic field compensation coils consist of

(1) a coil that is wrapped centering on the aforementioned z axis and generates magnetic fields in the z axis direction,

(2) a coil that is wrapped about an axis parallel to the x axis and generates magnetic fields in the x axis direction,

(3) a coil that is wrapped about an axis parallel to the y axis and generates magnetic fields in the y axis direction (Claim 4).

[0013] In this means, as will be explained below using drawings in the embodiments, it is possible to incorporate the magnetic field detection coil and the magnetic field generation coil into a narrow space within the charged particle beam exposure apparatus. Therefore, the charged particle beam exposure apparatus never becomes large.

[0014] The fifth means to solve the aforementioned problems is any of the aforementioned first through fourth means; characterized in that the aforementioned magnetic sensor is provided so as to be separated from the aforementioned z axis direction further than the aforementioned magnetic

field compensation coil (Claim 5).

[0015] In this means, the magnetic sensor is provided at a position separated from the z axis, so external magnetic fields can be accurately detected. Also, the magnetic field compensation coil is provided near the z axis, so it is possible to effectively compensate magnetic fields in the vicinity of the optical axis.

[0016] The sixth means to solve the aforementioned problems is any of the aforementioned first through fourth means; characterized in that the aforementioned magnetic sensor consists of a coil, and this coil also acts as a magnetic field compensation coil (Claim 6).

[0017] In this means, the magnetic sensor and magnetic field compensation coil are combined, so commensurate reduction of components is possible, and the apparatus can be made more compact. However, in using this means, rather than regulating the electric current that flows to this coil so that the magnetic field detected by the coil becomes 0, the question of what multiple of the detected magnetic field the generated magnetic field should be is experimentally

answered, a compensation electric current is caused to flow according to that ratio, and, for the first time, the effects of external magnetic fields can be completely compensated.

[0018] In addition, by using a method whereby coil is used as the magnetic sensor to measure the floating magnetic field between exposure transfers and coil is used as the magnetic field compensation coil during exposure transfer and an electric current that would negate the measured floating magnetic field is caused to flow, the floating magnetic field can be negated.

[0019] The seventh means to solve the aforementioned problems is the charged particle beam exposure apparatus adjustment method of any of the aforementioned first through sixth means; characterized in that the ratio of the magnetic field detected by the magnetic sensor and the electric current that flows to the magnetic field compensation coil is experimentally obtained in advance, and the electric current that flows to the compensation coil is determined based on the actually detected magnetic field and this

ratio (Claim 7).

[0020] In this means, the ratio of the magnetic field detected by the magnetic sensor and the electric current that flows to the magnetic field compensation coil, which is required to negate that magnetic field, is experimentally obtained in advance, and the electric current required to negate the fluctuating magnetic field can be accurately provided to the magnetic field compensation coil.

[0021] The eighth means to solve the aforementioned problems is a semiconductor device method of manufacture characterized in that it results from having a process that uses any of the aforementioned first through sixth means and exposure transfers the image of the pattern formed on a mask or a reticle onto a mask (Claim 8).

[0022] In this means, exposure transfer is performed using a charged particle beam exposure that is not likely to be affected by floating magnetic fields, so it is possible to manufacture semiconductor devices that have minute patterns with high precision.

[0023] [Embodiment of the Invention]

An example of an embodiment of the present invention will be explained below using drawings. FIG. 1 is a drawing that shows an overview of the charged particle exposure apparatus that is an example of an embodiment of the present invention. In FIG. 1, 1 is an electron gun, 2 and 3 are condenser lenses, 4 is a beam formation aperture, 5 is an illumination lens, 6 is a ferrite stack, 7 is a deflecting coil (and dynamic compensation lens), 8 is a search coil, 9 is a compensation coil, 10 is a reticle, 11 is the first projection lens, 12 is a lens core, 13 is the second projection lens, 14 is a lens core, 15 is an external magnetic field detection circuit, 16 is an external magnetic field compensation circuit, 17 is a ferrite stack, 18 is a deflecting coil, 19 is a dynamic compensation lens, 20 is a dynamic astigmatic compensation lens, 21 is a search coil, 22 is a compensation coil, 23 is a wafer, 24 is a ferrite stack, 25 is a deflecting coil, 26 is a dynamic compensation lens, 27 is a dynamic astigmatic compensation lens, 28 is an external magnetic field

detection circuit, and 29 is an external magnetic field compensation circuit.

[0024] An electron beam emitted from the electron gun 1 is condensed by the condenser lenses 2, 3, and the beam formation aperture 4 is illuminated at uniform strength. The electron beam formed by the beam formation aperture 4 illuminates one subfield of the reticle 10 by means of the illumination lens 5. The electron beam, which has been formed into a pattern by the reticle 10, projects the image of the pattern of the reticle 10 onto a wafer 23 by means of the first projection lens 11 and the second projection lens 13. When exposure transfer of one subfield is completed, the electron beam is deflected by the deflecting coil 7, and the next subfield in the main deflection direction is illuminated.

[0025] In this way, after the subfields in the main deflection direction are scanned by defection and sequentially exposure transferred, the reticle and the wafer are continuously moving, so a status results in which it is possible to perform exposure transfer of the subfields of

the next stage in a direction that is perpendicular to the main deflection direction. This is repeated so that all reticle patterns are transferred to all wafers. The actions of the dynamic compensation lens, the ferrite stack, etc. are well known, and explanations of these will be omitted, as they are not directly related to the present invention.

[0026] In the present embodiment of the invention, search coil (magnetic field detector) 8, which detects external magnetic fields, and compensation coil (magnetic field compensation coil) 9 are provided below the illumination lens 5 at positions such as those shown in the drawing. The external magnetic field detected by search coil 8 is changed to an electrical signal by external magnetic field detection circuit 15 and is provided to external magnetic field compensation circuit 16. External magnetic field compensation circuit 16 negates the external magnetic field by providing to compensation coil 9 an electric current that corresponds to the detected external magnetic field.

[0027] As shown in the drawing, in the same way, at the lower side of the second projection lens 13 as well are provided

a search coil 21 and a compensation coil 22. The external magnetic field detected by search coil 21 is changed to an electrical signal by external magnetic field detection circuit 28 and provided to external magnetic field compensation circuit 29. External magnetic field compensation circuit 29 negates the external magnetic field by providing to compensation coil 2 an electric current that corresponds to the detected external magnetic field.

[0028] FIG. 2 shows an example of the actual arrangement of the search coil and the magnetic field compensation coil. In FIG. 2, (a) is the A-A'cross section, and (b) is a drawing that views the top from the B-B'position. 31 is a z axis direction magnetic field compensation coil, 32 is an x axis direction magnetic field compensation coil, 33 is a y axis direction magnetic field compensation coil, 34 is a z axis direction search coil, 35 is an x axis direction search coil, 36 is a z axis direction search coil, 37 is the pole piece of the illumination lens 5, and 38 is the pole piece of the first projection lens 11.

[0029] The search coils and the magnetic field compensation coils of the respective axis directions are attached to the pole piece of the illumination lens 5. At the centermost axis side, the z axis direction magnetic field compensation coil 31 is wrapped around concentrically so that it goes around the z axis, and by causing an electric current to flow to the coil, the magnetic field in the z axis direction is formed to be axially symmetrical centering on the z axis.

[0030] Outside this, the x axis direction magnetic field compensation coil 32 and the y axis direction magnetic field compensation coil 33 are provided. The x axis direction magnetic field compensation coil 32 is wrapped around in a saddle-like way between -45° and +45° in the drawing at a position that has y axis symmetry with this. This causes an x axis direction magnetic field to be generated. Of course, the two coils that mutually have y axis symmetry are such that they generate an x axis direction magnetic field facing the same way.

[0031] In the same way, the y axis direction magnetic field compensation coil 33 is wrapped around in a saddle-like way between 45° and 135° in the drawing at a position which has x axis symmetry with this. This causes a y axis direction magnetic field to be generated. Of course, the two coils that mutually have x axis symmetry are such that they generate a y axis direction magnetic field facing the same way.

[0032] Outside this, the z axis direction search coil 34 is wrapped around by the same method as the z axis direction magnetic field compensation coil 31, and it is such that it detects only z axis direction magnetic fields. In addition, outside this, the x axis direction search coil 35 and the y axis direction search coil 36 are wrapped around by the same method as the x axis direction magnetic field compensation coil 32 and the y axis direction magnetic field compensation coil 33, and they such that they respectively detect only x axis direction magnetic fields and y axis direction magnetic fields.

[0033] In this type of arrangement, the reason that the respective search coils are provided outside the magnetic field compensation coils is that the design is such that the magnetic field resulting from the deflector provided in the body tube interior and the magnetic field resulting from the dynamic focus lens do not reach the search coils, and the search coils are able to detect only external magnetic fields. In contrast with this, the magnetic field compensation coils are provided close to the optical axis so that compensation can be performed by as small an electric current as possible.

[0034] The above are examples of search coils and magnetic field compensation coils provided in the interval between the illumination optical system and the projection optical system, but those provided between the interval between [sic?] the projection optical system and the wafer stage can also be realized with the same configuration.

[0035] The following method is an example of a method of performing compensation using search coils and magnetic field compensation coils with this type of arrangement.

Specifically, a Helmholtz coil is placed at a position that is sufficiently separated from the optical axis, and a uniform magnetic field is generated. At this time, the electric current I_{s8} that flows to the search coils and the amount of shake of the beam on the optical axis will be detected.

[0036] Then, an electric current is caused to flow to the magnetic field compensation coil in this status to provide a compensation magnetic field, and beam shake is brought to 0. If the value of electric current that flowed to the magnetic field compensation coil when beam shake returned to 0 is I_{c8}, the ratio of this I_{c8} and I_{s8} is $I_{c8}/I_{s8} = k$. At the time of compensation, if an I_s electric current is detected by the search coil, an electric current that is k times this is made to flow to the magnetic field compensation circuit. This is implemented independently in the x, y and z axis directions. Instead of looking at beam shake, it would also be acceptable to place a magnetic field detector in the vicinity of the optical axis and perform an adjustment such as the above with this as the

standard.

[0037] In addition, in the above embodiment, the search coil and the magnetic field compensation coil are separately provided, but these may be shared as well. Specifically, how many times the value of the electric current detected by the coil the opposite phase electric current must be to bring beam shake to 0 can be experimentally determined in advance, and an electric current that corresponds to that ratio can be caused to flow. In addition, in a step and repeat exposure apparatus, there is a prescribed time interval from exposure of one subfield to exposure of the next subfield, so measurement of the external magnetic field is performed at this time, and external magnetic field compensation may be performed using the same coils during exposure.

[0038] Below, an example of an embodiment of the semiconductor device method of manufacture relating to the present invention will be explained. FIG. 3 is a flowchart that shows an example of the semiconductor device manufacturing method of the present invention. The manufacturing process

of this example includes the following respective main processes.

(1) A wafer manufacturing process for manufacturing a wafer (or a wafer preparation process for preparing a wafer)

(2) A mask manufacturing process for making the mask used in exposure (or a mask preparation process that prepares a mask)

(3) A wafer processing process for performing the processing treatment required by the wafer

(4) A chip assembly process in which chips formed on the wafer are cut out one at a time to render them operable

(5) A chip inspection process for inspecting the chips made

Note that the respective processes consist of a number of sub-processes.

[0039] Among these main processes, the main process that has a decisive effect on the performance of the semiconductor device is the wafer processing process. In this process, the designed circuit pattern is sequentially laminated onto the wafer, and a plurality of chips that operate as memories and MPUs are formed. This wafer processing process

includes the following respective processes.

(1) A thin film formation process that forms the dielectric thin film that is the insulating layer or a metal thin film, etc. that forms the wiring portion or the electrode portion (CVD or spattering, etc. is used)

(2) An oxidation process that oxidizes this thin film layer or the wafer substrate

(3) A lithography process that forms the pattern of the resist using a mask (reticle) for selectively processing the thin film layer, the wafer substrate, etc.

(4) An etching process that processes the thin film layer or the substrate according to the resist pattern (for example, using dry etching technology)

(5) An ion/impurity implantation dispersion process

(6) A resist peeling process

(7) An inspection process for inspecting the processed wafer further

Note that the wafer processing process is repeated for the required number of layers to manufacture a

semiconductor device that will operate according to the design.

[0040] FIG. 4 is a flowchart that shows the lithography process that is the nucleus of the wafer processing process of FIG. 3. This lithography process includes the following respective processes.

(1) A resist coating process that coats the resist onto the wafer on which a circuit pattern was formed in the process of the preceding stage

(2) An exposure process that exposes the resist

(3) A development process that develops the exposed resist to obtain a resist pattern

(4) An annealing process for stabilizing the developed resist pattern

The above semiconductor device manufacturing process, wafer processing process and lithography process are well known, and we do not feel that a further explanation is required. In the embodiment of the present invention, a charged particle beam exposure apparatus relating to the present invention is used in the exposure process of the

lithography process. Therefore, it is not easily susceptible to the effects of floating magnetic fields, and it is capable of accurate exposure transfer, so it is possible to manufacture a semiconductor device having minute patterns with high precision.

[0041] [Effects of the Invention]

As explained above, in the invention of the present invention that relates to Claim 1, it is possible to achieve an effect that combines with the shielding effect of the ferromagnetic bodies of the envelope of the illumination optical system and the projection optical system without the need for large equipment, so it is possible to easily obtain a good floating magnetic field shielding ratio.

[0042] In the invention relating to Claim 2, it is possible to pursue effective utilization of space.

In the invention relating to Claim 3, it is possible to reliably negate fluctuating magnetic fields.

In the invention relating to Claim 4, the charged particle beam exposure apparatus is never made large.

[0043] In the invention relating to Claim 5, a magnetic sensor is able to accurately detect external magnetic fields, and a magnetic field compensation coil is able to effectively compensate magnetic fields in the vicinity of the optical axis.

In the invention relating to Claim 6, it is possible to reduce the number of coils.

[0044] In the invention relating to Claim 7, it is possible to accurately provide the electric current required to negate the fluctuating magnetic field to the magnetic field compensation coil.

In the invention relating to Claim 8, it is possible to manufacture a semiconductor device that has minute patterns with high precision.

[Brief Explanation of the Drawings]

FIG. 1 A drawing that shows an overview of a charged particle beam exposure apparatus that is an example of the embodiment of the present invention

FIG. 2 A drawing that shows an example of the actual arrangement of the search coils and the magnetic field

compensation coils

FIG. 3 A flowchart that shows an example of the semiconductor device method of manufacture the present invention

FIG. 4 A flowchart that shows the lithography process

[Explanation of Codes]

1	electron gun
2, 3	condenser lens
4	beam formation aperture
5	illumination lens
6	ferrite stack
7	deflecting coil (and dynamic compensation lens)
8	search coil
9	compensation coil
10	reticle
11	first projection lens
12	lens core
13	second projection lens
14	lens core
15	external magnetic field detection

circuit

16 external magnetic field compensation

circuit

17 ferrite stack

18 deflecting coil

19 dynamic compensation lens

20 dynamic astigmatic compensation lens

21 search coil

22 compensation coil

23 wafer

24 ferrite stack

25 deflecting coil

26 dynamic compensation lens

27 dynamic astigmatic compensation lens

28 external magnetic field detection

circuit

29 external magnetic field compensation

circuit

31 z axis direction magnetic field

compensation coil

32 x axis direction magnetic field compensation coil

33 y axis direction magnetic field compensation coil

34 z axis direction search coil

35 x axis direction search coil

36 z axis direction search coil

37 pole piece of illumination lens 5,

38 pole piece of first projection lens 11

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FIG. 1

FIG. 2

FIG. 3

1.	Wafer manufacturing process
2.	Wafer
3.	Wafer processing process
4.	Chip assembly process
5.	Chip
6.	Chip inspection process
7.	Product (semiconductor device)
8.	CVD
	Spattering
	Oxidation
	Ion implantation
	Dry etching
9.	Mask manufacturing process
10.	Reticle, mask
11.	Mask inspection process
12.	Lithography process
13.	Inspection process
14.	Repetition

FIG. 4

1.	Resist coating process
2.	Exposure process
3.	Development process
4.	Annealing process

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Summary

Issue: To provide a charged particle beam exposure apparatus that is able to negate the effects of floating magnetic fields and which has a good shielding ratio without using a large apparatus.

Solution means: A search coil 8 that detects external magnetic fields and a compensation coil 9 are provided below the illumination lens 5 at positions such as those shown in the drawings. The external magnetic field detected

by search coil 8 is changed into an electrical signal by an external magnetic field detection circuit 15 and provided to an external magnetic field compensation circuit 16. External magnetic field compensation circuit 16 negates the external magnetic field by providing an electric current that corresponds to the detected external magnetic field to compensation coil 9. While, as shown in the drawing, a search coil 21 and a compensation coil 22 are provided in the same way below the second projection lens 13 as well, external magnetic field detection circuit 28 and external magnetic field compensation circuit 29 are provided. These operate in the same way as those provided below illumination lens 5.

Selected drawing: FIG. 1

* * *

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